Heat Pumps:

- Why are they necessary
- How do they work
- How do I install one
- My own Heat Pump journey

Richard Croucher

About Me

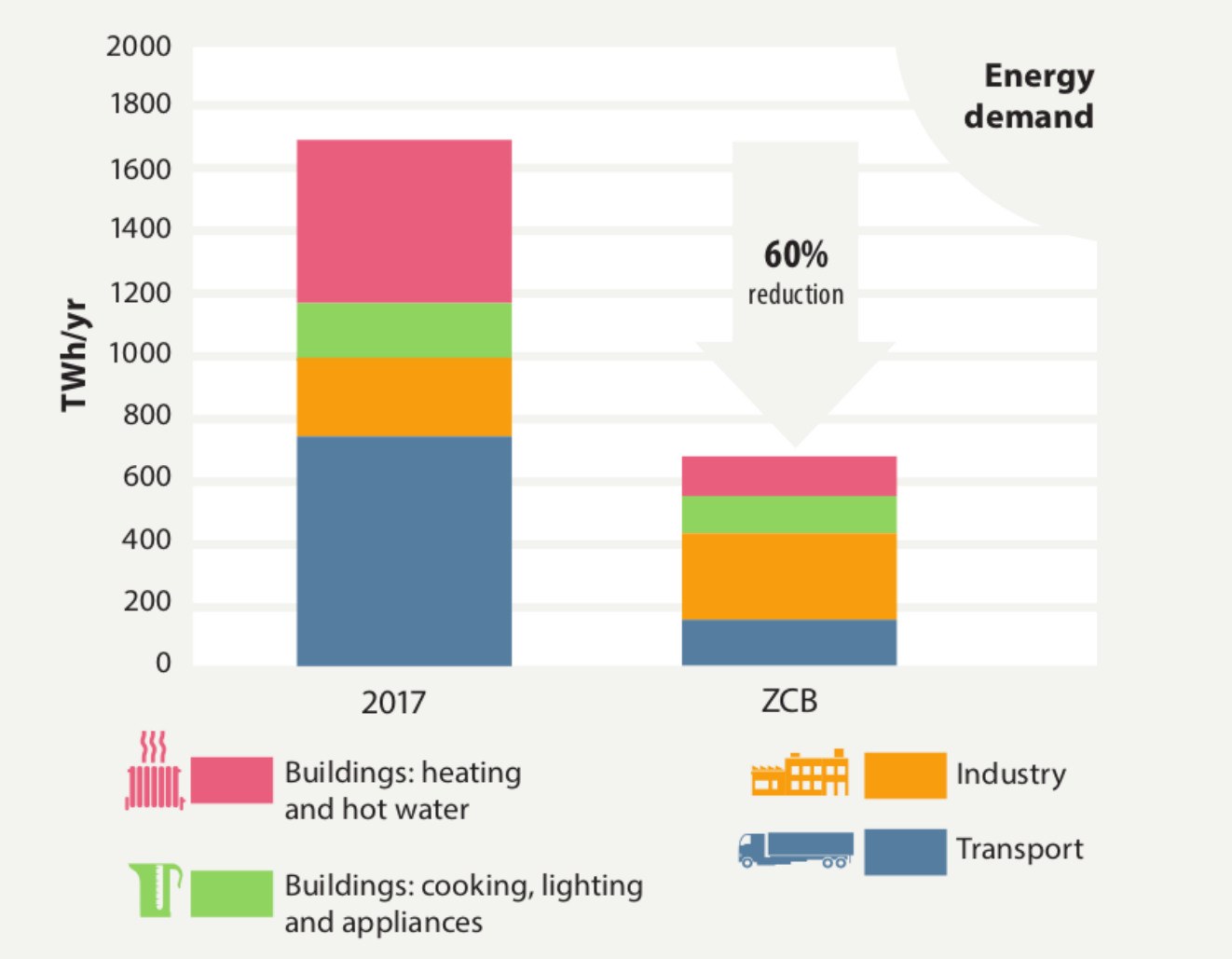
Not MCS Certified, installer or representative of a heat pump company

- Distinguished Engineer
- Fellow STAC Research
- FBCS - Fellow British Computer Society
- CITP - Chartered IT Practitioner
- Applied Physics - University of East London
- Electronics - Thames Valley University
- Materials Science and NDT - Brunel University

Deeply concerned about the damage our Co2 is doing and the problem it leaves future generations

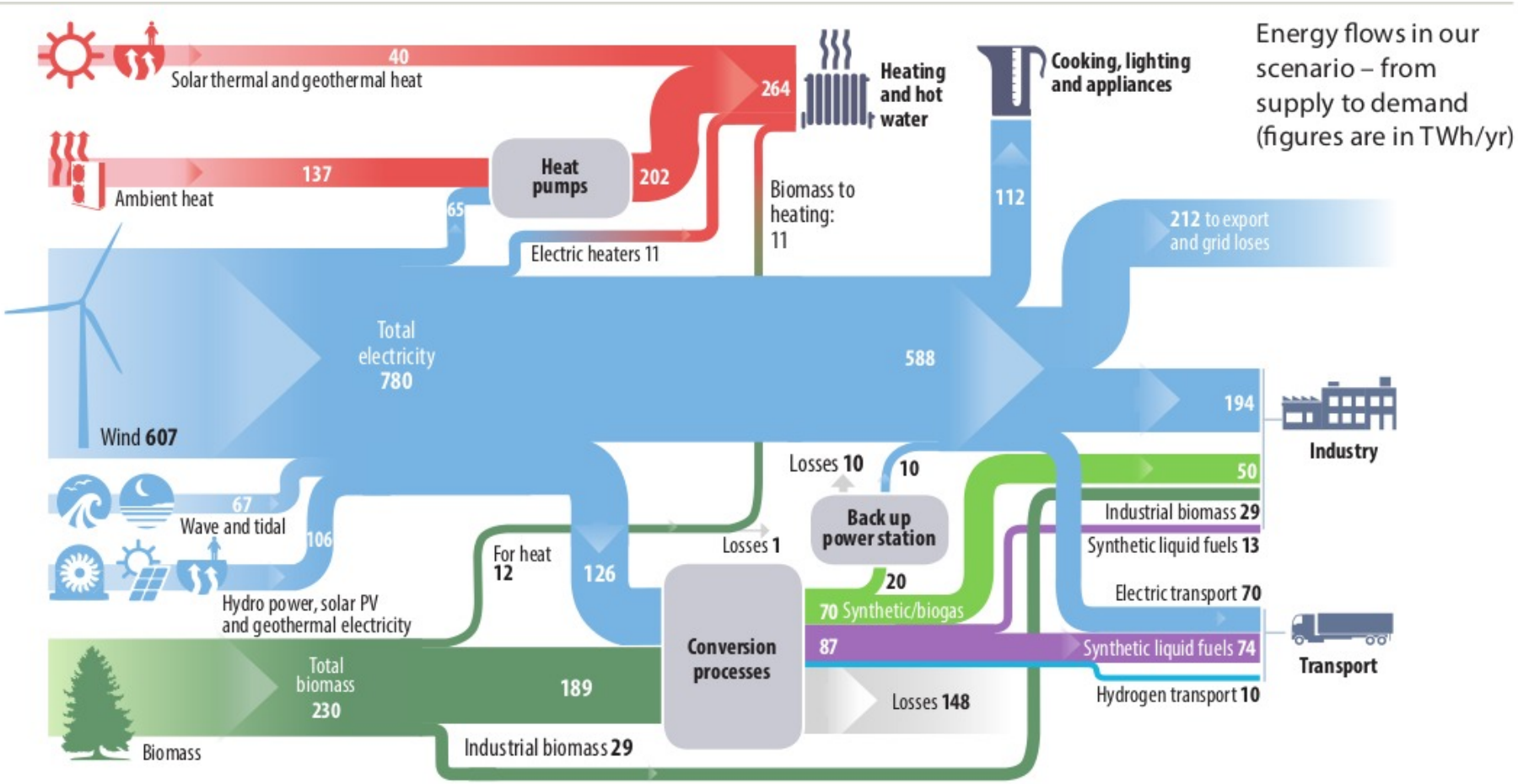
- Driving PHEV since 2017
- Driving BEV since Feb 2020
- GSHP - started researching in 2019, installed July 2020 - totally Fossil fuel free since

2017 Energy Mix v. Zero Carbon Britain



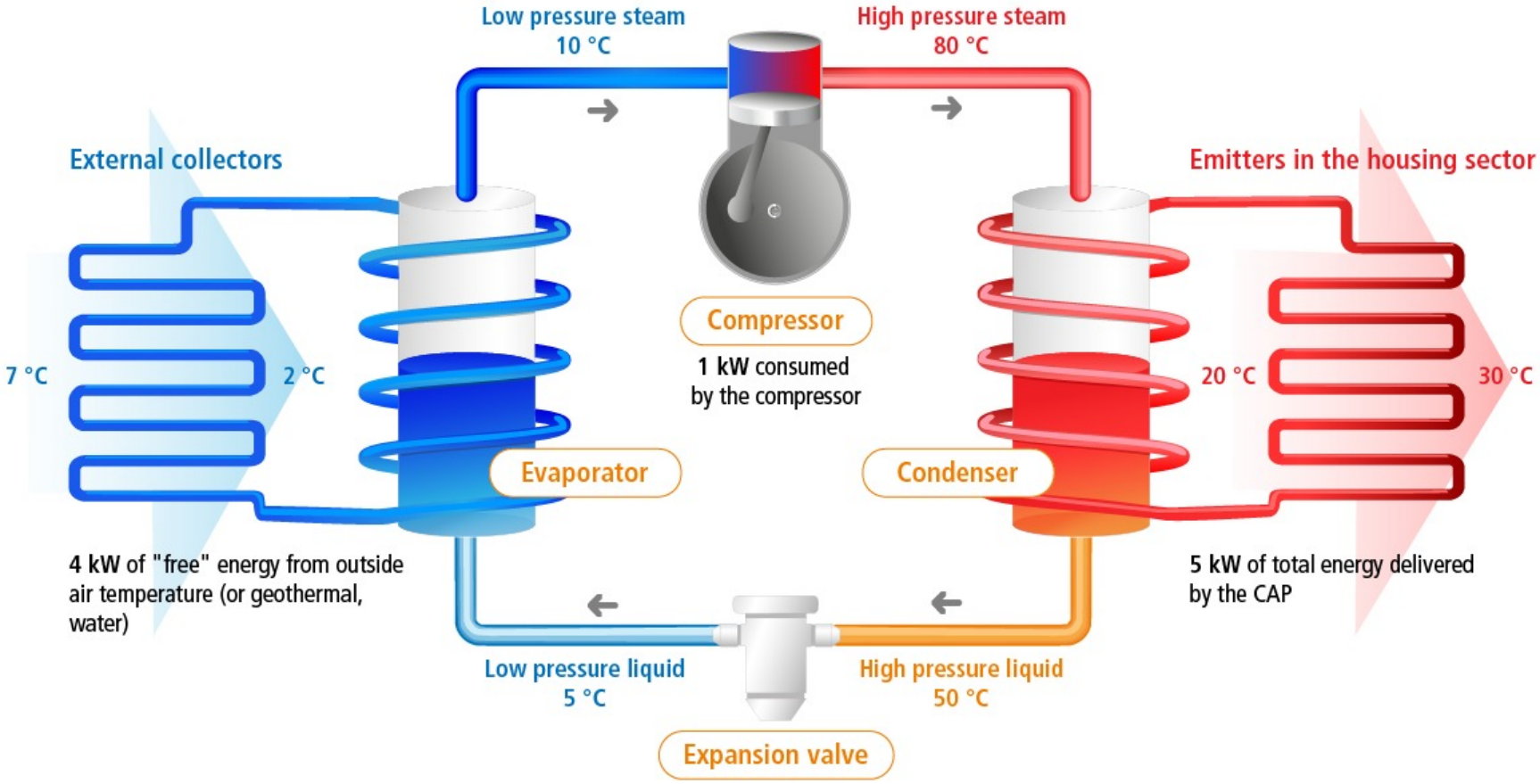
Zero Carbon Britain - Rising to the Climate Emergency, Centre For Alternate Technology, www.cat.org.uk, 2019

Electricity consumption ZCB



Zero Carbon Britain - Rising to the Climate Emergency, Centre For Alternate Technology, www.cat.org.uk, 2019

How a Heat Pump works



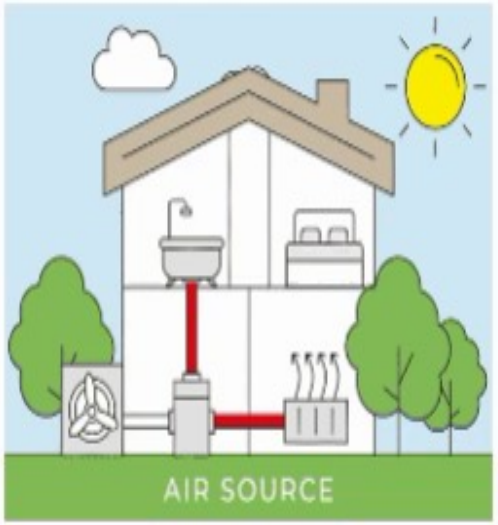
Heat Pump - Step by Step

1. Ensure your insulation is up to scratch – 600m loft, double glazing, cavity wall insulation
2. Arrange Heat loss Report to determine energy requirements – approx. £350
3. Consider which HP options would work for you – Air Source, Slinkies, bore holes, open water, passive solar
4. Discuss options with potential MCS certified installers who can meet your requirements - https://mcscertified.com/find-an-installer/
5. Shortlist installers – reviews, companies house - financially sound, similar projects, reference call with similar clients, county court judgements
6. Sign-off on design before committing - predicted running cost, all parts, where they go, house holder obligations, installer expectations
7. Install happens 

8. Installer handover - instructions, warranty, MCS certificate (this indicated energy saved)
9. Obtain a Energy Performance Certificate (EPC) must show no requirement for further insulation - approx £85
10. Arrange RHI on their website – requires MCS and EPC certificate numbers. Typically approved automatically within 48 hours. Paid quarterly for 7 yearsi

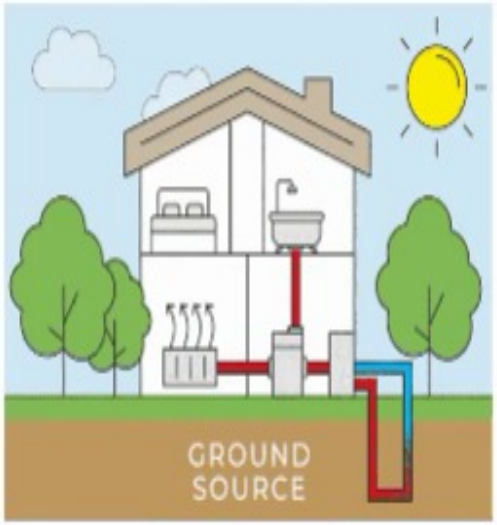
Heat Pump Types

AIR SOURCE HEAT PUMPS



LEARN MORE

GROUND SOURCE HEAT PUMPS



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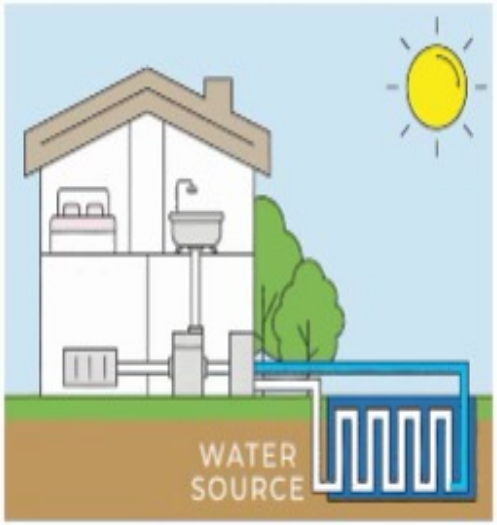
WATER SOURCE HEAT PUMPS



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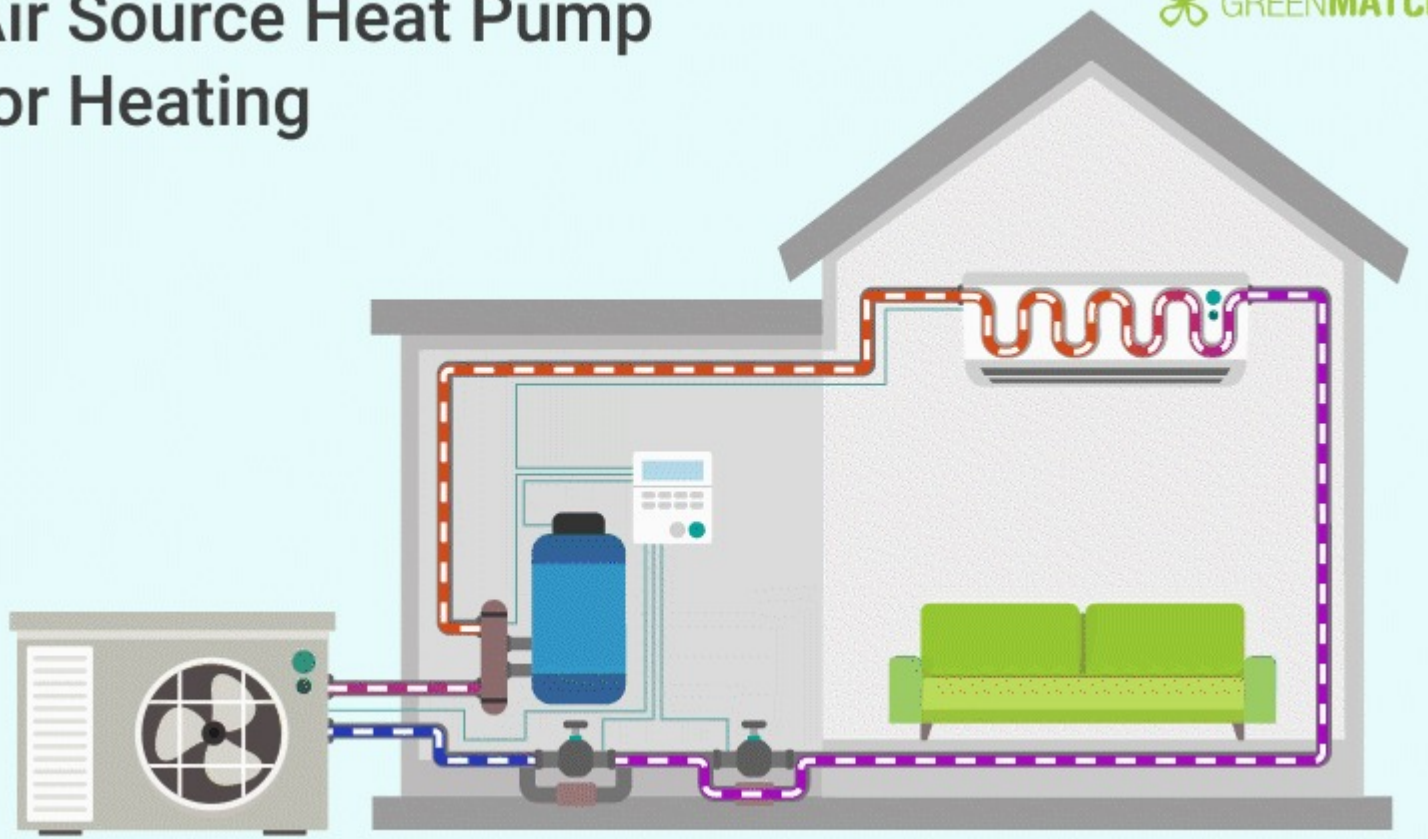
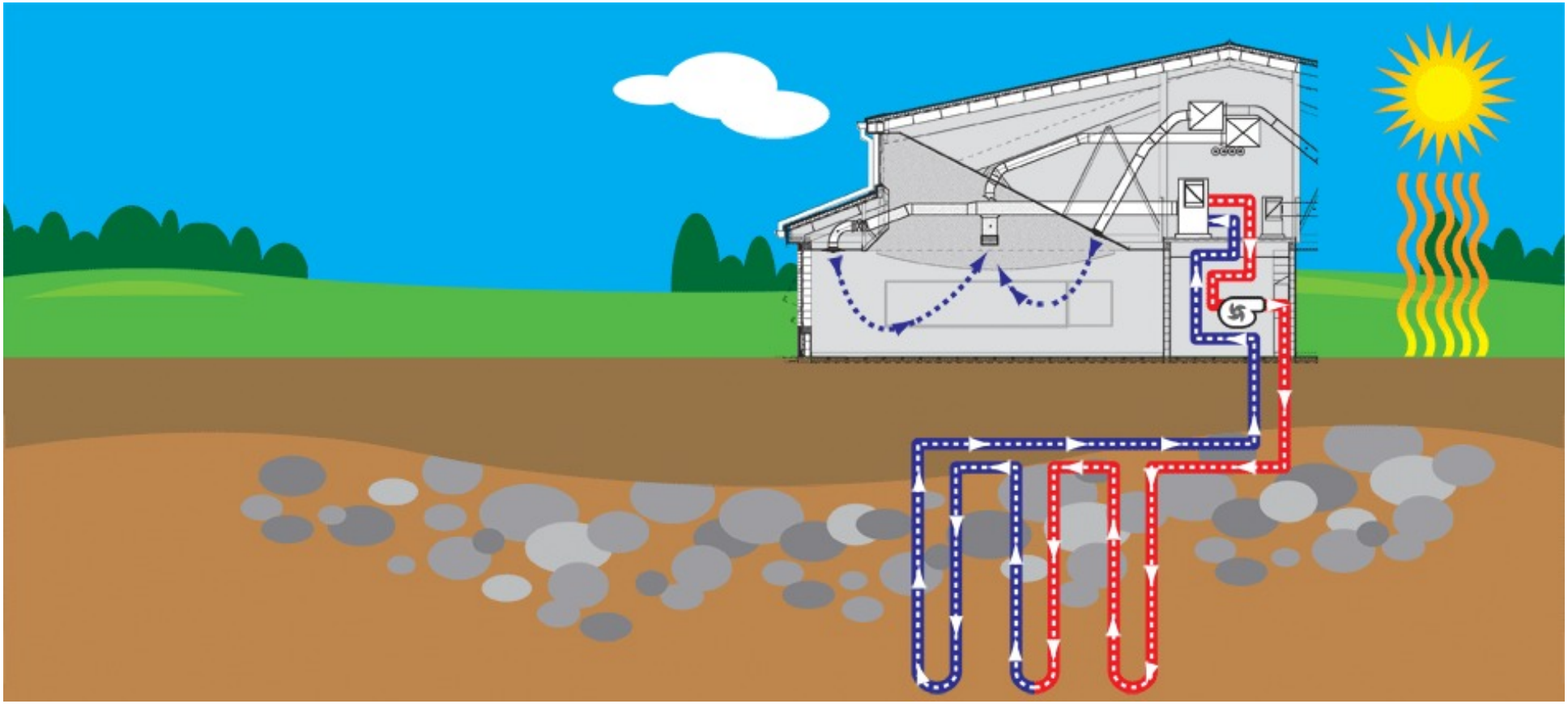
Air Source Heat Pump for Heating



Ground Source Heat Pump

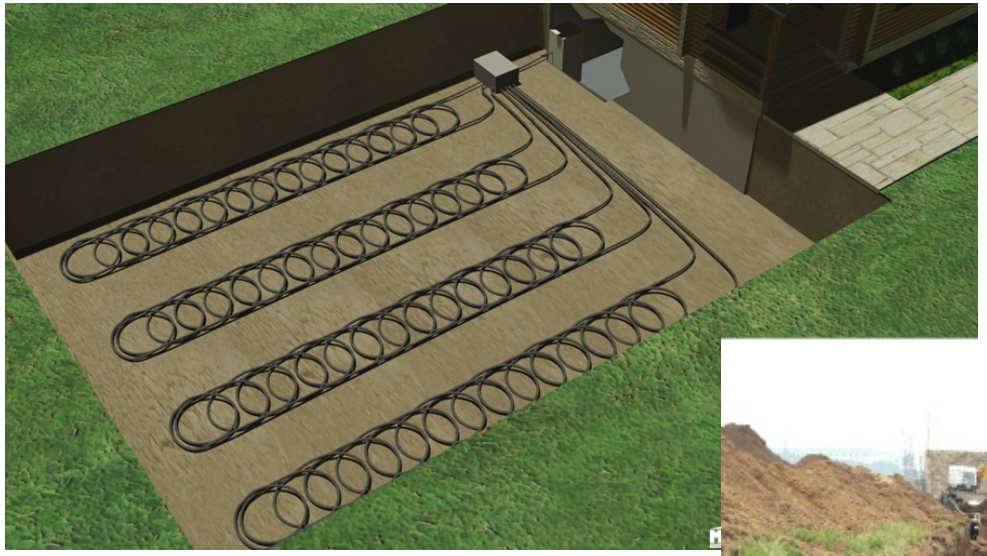


Rough Guide - 100m of bore hole per 5KW demand

Dependency on ground type – see British Geological Data
https://www.bgs.ac.uk/information-hub/borehole-records/

Slinkies - trenched GSHP

(Cheaper than bore holes, but...)



Rough Guide:
300 sq. metre of collection (50m trench)
per 5KW demand

Solar heat collectors

- Gather heat from sun
- Highest temperature zero carbon energy source
- Types:
  - Evacuated tubes
  - Passive panels
- Can be used in combination with other collectors
- Ideal for complementing GSHP's to increase efficiency in summer

https://energysavingtrust.org.uk/advice/solar-water-heating/

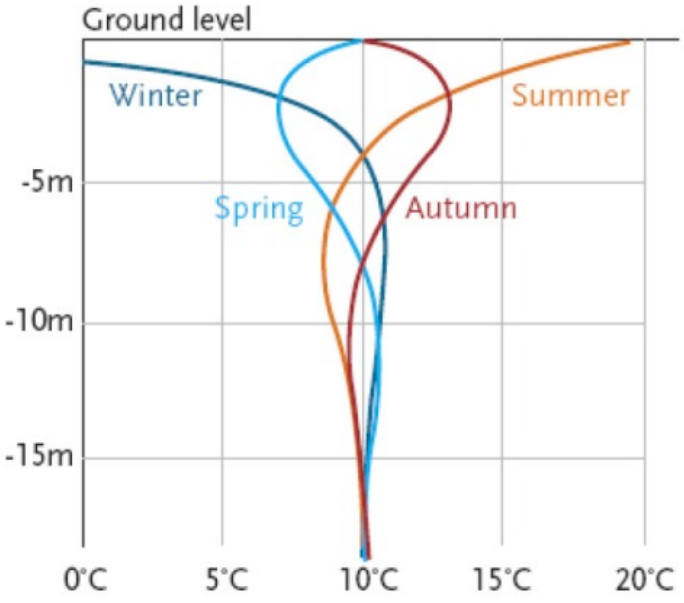
Heat Pump Efficiency - COP

Coefficient of Performance
Ratio of output heat for input energy

e.g at a COP of 5
5KW heat generated for 1KW electricity in

COP decreases as you increase outflow temperature or decrease inflow temperature.

Expressed as Seasonal COP (SCOP)



Approximate UK Annual Ground Temperatures

Air source is least efficient
Just when you need it the most

Ground source has benefit of
Stable inflow temperature

Flow temperature	SCOP
35°C	4.37
36°C	4.29
37°C	4.21
38°C	4.14
39°C	4.06
40°C	3.98
41°C	3.91
42°C	3.83
43°C	3.76
44°C	3.68
45°C	3.6
46°C	3.59
47°C	3.58
48°C	3.56
49°C	3.55
50°C	3.53
51°C	3.52
52°C	3.5
53°C	3.49
54°C	3.47
55°C	3.46

Renewables encouraged and regulated by grants in UK

RHI grant funded 67% of my costs so vital to be compliant

The Renewable Energy Consumer Code is approved by Chartered Trading Standards Institute **www.tradingstandards.gov.uk**

The Code dovetails with the Microgeneration Certification Scheme (MCS), an important quality assurance mechanism that certifies installers and products in the sector **www.microgenerationcertification.org**

Certification to the MCS standards is a requirement of the Government's Feed-In Tariffs scheme. See:
www.gov.uk/feed-in-tariffs

Certification to the MCS standards is also a requirement of the Government's Domestic Renewable Heat Incentive.
See: **www.gov.uk/domestic-renewable-heat-incentive**

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UK Renewable Heat Incentive

- Renewable Heat Incentive (RHI) partially funds Heat Pumps in UK
  - No longer incentives for PV's in UK
    - feed-in tariff now set by supplier (1.5 - 5.5p per KW/H)
    - compared with typical 12-16p KW/H purchase cost
- Amount is dependent on energy saved
- RHI lays down requirements for suppliers and installers
  - must be MCS certified and recent Energy Performance Certificate (EPC) which shows no requirement for further insulation
- RHI paid out quarterly over 7 years and tariff determined by your entry rate
- Any other grants e.g. £10K Green Homes Grant subtracted from RHI payments
- Contingent on continued usage – annual declaration
- MCS requires usage meter as part of installation so could be audited

Estimating your RHI

Biomass (p/kWh)	ASHP (p/kWh)	GSHP (p/kWh)	Solar thermal (p/KWh)
7.01	10.92	21.29	21.49

domestic_rhi_tariff_table_2021-22_1

- From your Heat Loss Report, establish the annual heating and hot water demand (kWh/yr). For example, 25,000kWh/yr.
- To calculate the ‘renewable’ content, first divide this by the heat pump SCoP, for example, 3.4*, to find the amount of electrical energy the heat pump will consume: 25,000 / 3.4 = 7353kWh/yr.
- Deduct this figure from the EPC total to calculate the ‘renewable’ content: 25,000 – 7353 = 17,647kWh/yr.
- Multiply this figure by the RHI tariff (for example, if it were 21.29p/kWh) to calculate the annual RHI payment: 17,647 x £0.2129 = £3,864 per year, each year for 7 years.
- Payment increases by CPI each year and is paid 7 years, regardless of future tariff changes

Example calculation Courtesy Kensa Heat Pumps UK

Current RHI ends 31st March 2022

- No confirmation of replacement
- Some speculation that they will merge with the now withdrawn Green Home Grant into a single scheme into a new ‘Clean Heat Grant’
  - Green Home Grant was a upfront payment of upto £10K which was then subtracted from eventual RHI. Failed under a mass of bureaucracy and was eventual withdrawn as un-workable
- Best information on what’s coming is:
  - https://www.gov.uk/government/consultations/clean-heat-grant-further-policy-design-proposals
- It does state the following:
  - BIOMASS only when heat pumps not appropriate
  - Householder will be given a voucher to pass to (MCS certified) installer who redeems it
  - Householder will require at least one quote from a (MCS certified) installer
  - Existing (domestic) buildings only - no new builds
- No specific mention of RHI so likely to still run in parallel as with GHG

Typical Heat Pump Plant room

Expansion Vessels (Brine, Rads, HWT)

Heat Pump

Control Unit

Hot water cylinder (increase volume due to lower temperature)

Buffer Tank (a.k.a. volumizer)

Typically 10 litres per KW

My personal heat pump journey

- Was using nearly 3000 litres of oil a year to heat my home
  - Generated 8.5 tonnes of Co2 per year compared with approx 2.1 tonnes driving a petrol car!
- What are options :
  - Solar PV’s
  - Wind generator
  - Hydrogen Gas heating
  - Biomass Heating
  - Overnight electricity storage heaters
  - Heat Pumps

Westbarn Heat Loss Report

Room by room analysis							Outside design temp. -2.8 ˚C	
Room name	Room no.	Room temp. [˚C]	Peak heat load [W]	Room area [m2]	Spec. peak heat load [W/m2]	Type of emitter	Design flow temp. [˚C]	Star rating
HALL & STAIRS	G01	18	1059	25	43	RAD	>60	NO STARS
STUDY	G02	21	961	15	63	RAD	>60	NO STARS
W/C	G03	18	368	5	75	RAD	>60	NO STARS
LOUNGE	G04	21	2219	44	51	RAD	60	★
DINING ROOM	G05	21	989	22	46	RAD	60	★
UTILITY	G06	18	646	11	60	RAD	>60	NO STARS
KITCHEN / BREAKFAST	G07	21	1733	32	54	RAD	>60	NO STARS
HALL & STAIRS	F01	18	950	35	27	RAD	>60	NO STARS
BEDROOM 03	F02	18	557	14	39	RAD	55	★★
DRESSING ROOM	F03	18	226	7	30	RAD	50	★★★
MASTER EN-SUITE	F04	22	298	7	46	TR	50	★★★
MASTER BEDROOM	F05	18	1144	27	42	RAD	>60	NO STARS
BATHROOM	F06	22	415	8	51	RAD	60	★
SHOWER ROOM	F07	22	327	6	59	RAD	60	★
BEDROOM 02	F08	18	640	22	30	RAD	55	★★
				278	m^2			
	Total Heat Load		12532	W				
			45	W/m^2				

The heat loss report complies with British Standard BS EN 12831 as specified by the Microgeneration Certification Scheme and uses Degree Day data from CIBSE Guide A (base temperature 15.5 °C) 1976-1995 and Mean Air Temp data (from MIS 3005 Appendix B).

You can download tool yourself for initial estimates but you will need a MCS certified submission for RHI
https://mcscertified.com/mcs-launch-new-improved-heat-pump-calculator/

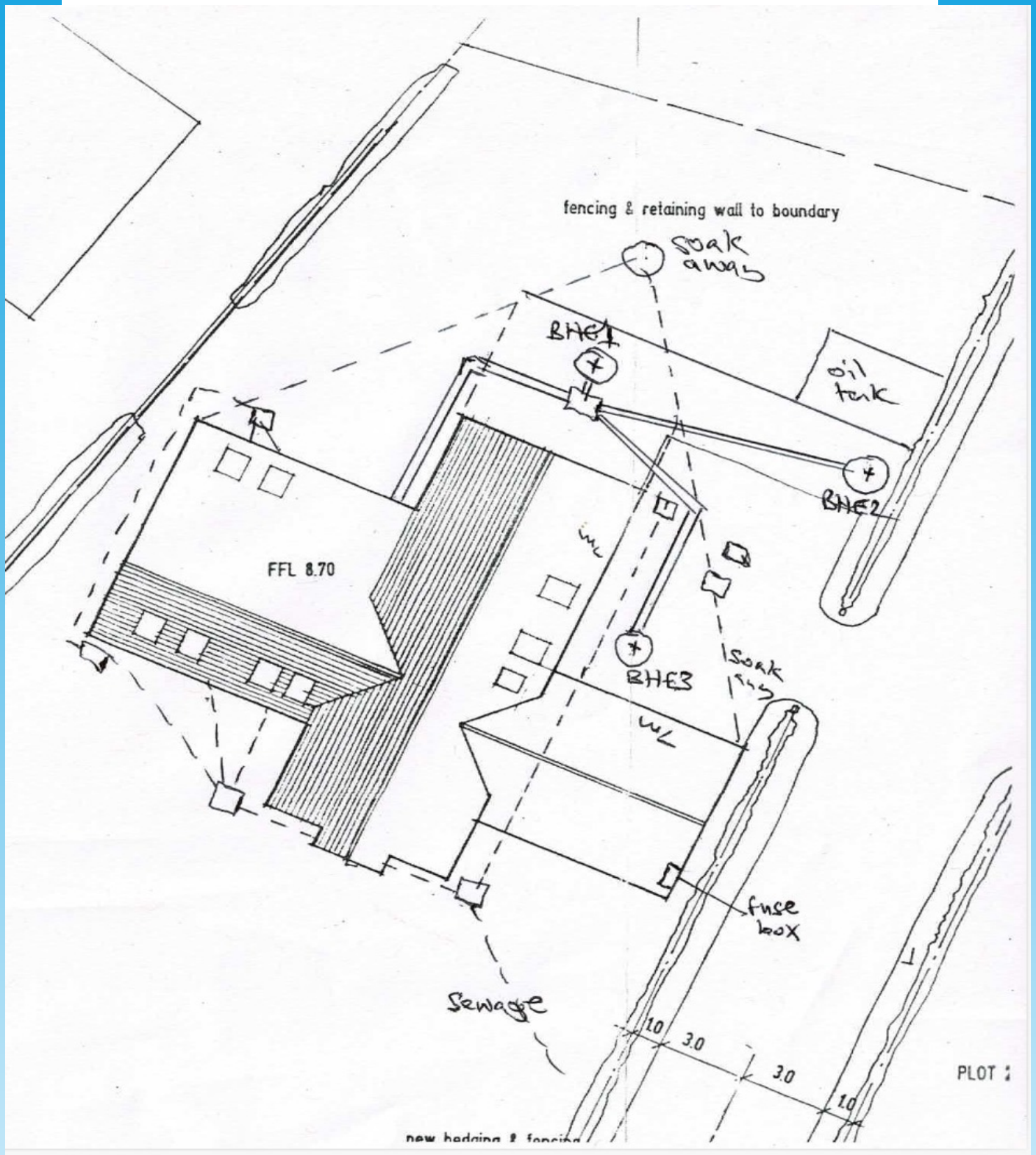
Sanity checked from actual oil consumption

	litres/oil	kw
number of days recorded	1370	
total oil for days	10822	
estimate per day	7.90	85
peak day (x4)	31.60	339.98
estimate per year	2875.3	30939
KG co2 per year	8511.0	0
peak hour consumption	1.3	14.2

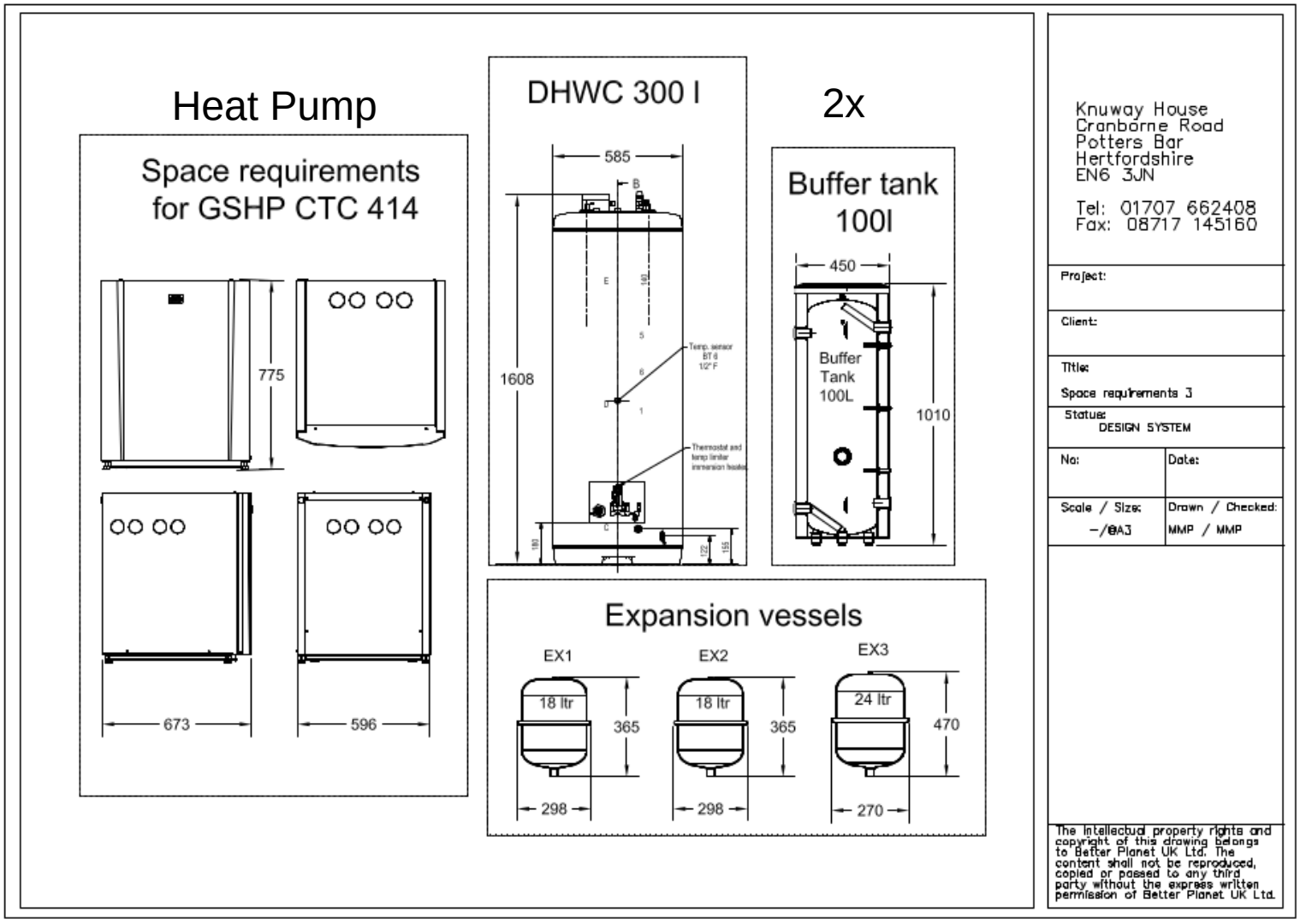
Survey predicted 12.5KW Heat Pump - went for 15KW to allow for hot water an a bigger safety margin

My Decision Process

- Obtained quotes, advice and performance reports from 3 potential installers for both ASHP and GSHP's
  - ASHP Perf Report - £19,300 install, ROI 13.8 years
  - GSHP Perf Report - £39,750 install, ROI 7.8 years
- Created my own cost model – GSHP ROI probably 8-10 years, Both Perf Reports over estimated SCOP and RHI
- ROI does not take into account increase in property value and future carbon tax impact
- Installer selection
  - Can it fit in current space? - Outline design, what goes where?
  - Previous similar installs
  - Customer references
  - Knowledge

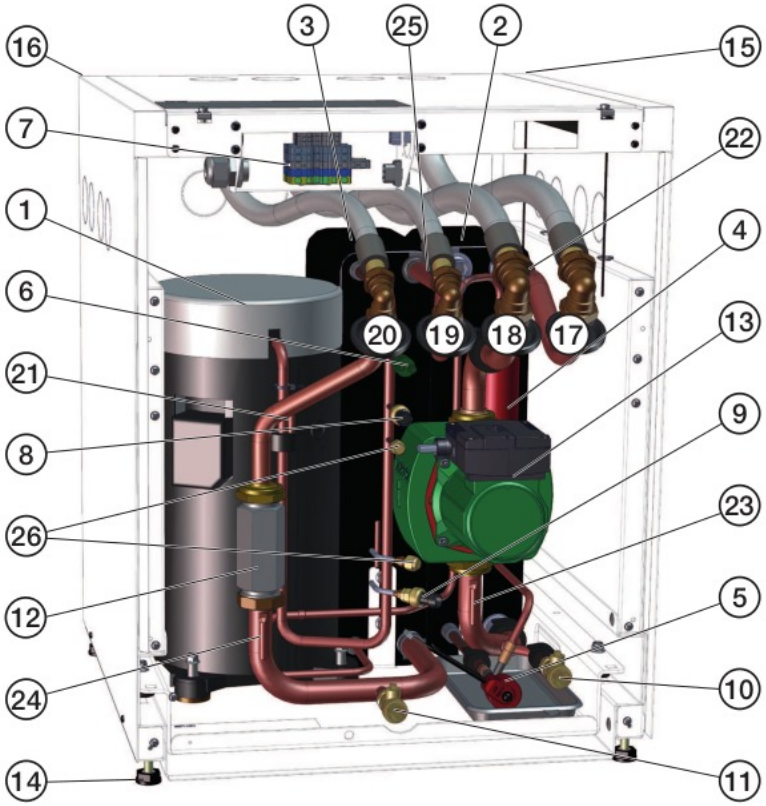

fencing & retaining wall to boundary
soak away
BHE1
oil tank
BHE2
FFL 8.70
WC
BHE3
soak away
WC
fuse box
Sewage
1.0
3.0
3.0
1.0
PLOT 1

Not just a heat pump to find space for



My CTC Heatpump

2.3 Component location

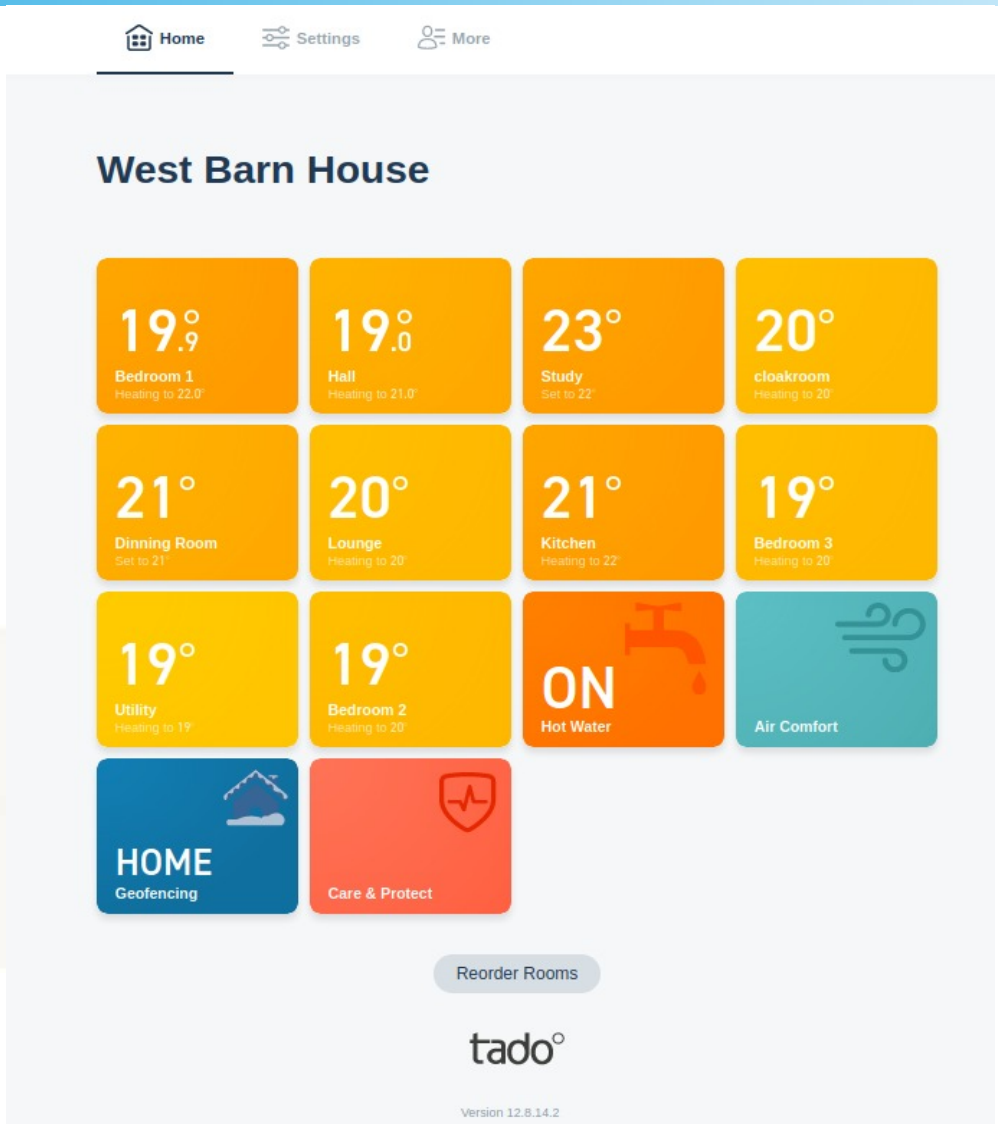


1. Compressor
2. Evaporator
3. Condenser
4. Drying filter
5. Expansion valve
6. High pressure switch
7. Terminal board
8. High pressure sensor
9. Low pressure sensor
10. Drain valve cold side/Brine
11. Drain valve warm side/Water
12. Adapter for pump installation
13. Circulation pump cold side
14. Adjustable feet
15. Conduit for communication cable
16. Conduit for mains cable
17. Brine in Ø28 mm (from rock)
18. Brine out Ø28 mm (to rock)
19. Heat medium out Ø22 (EcoHeat 406-412)
    Heat medium out Ø28 (EcoHeat 414-417)
20. Heat medium in Ø22 (EcoHeat 406-412)
    Heat medium in Ø28 (EcoHeat 414-417)
21. Hot gas sensor
22. Brine sensor in
23. Brine sensor out
24. Condenser sensor in
25. Condenser sensor out
26. Service socket

Consider Upgrade Central Heating control system

- Oil boiler at 35KW, 65c flow, could warm up entire house from cold rapidly
- Now need to accomplish same comfort levels with only 15KW and 45c flow
- Need to avoid the early morning switch-on
- Hindered by conventional radiators – underfloor heating is much better for Heat Pumps
  - Standard advice is to replace existing rads with larger units
- I replaced 2 zone, time programmer with Wireless TRV (Temperature Controlled Radiator Valves) and only replaced 3 rads
  - Heating is now on 24 hours but with lower temperatures set overnight and different room temp’s based on expected occupancy
  - get the heat to where you want it, when you want it

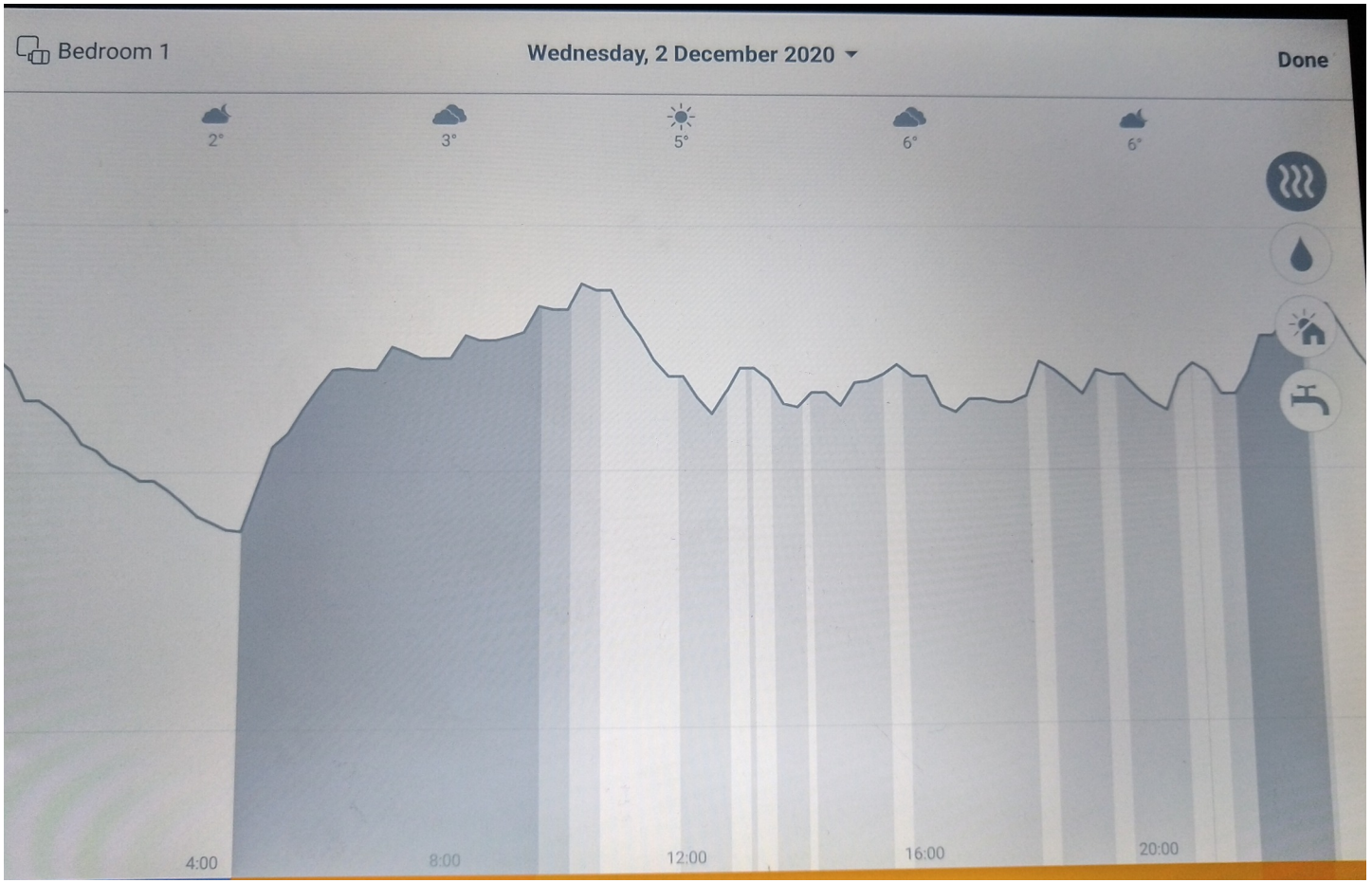
Tado



Saved increasing most radiator sizes like all installers recommended

Tado Room Heat Requests

Temp

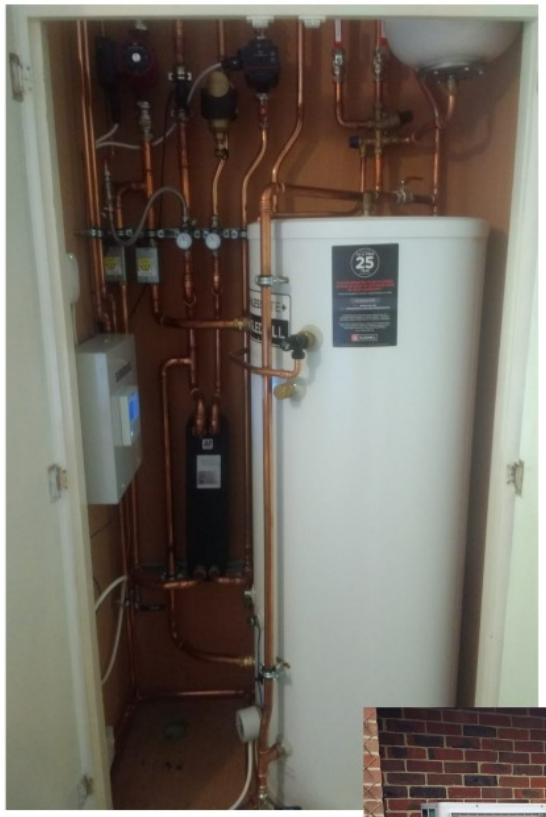


Shaded area’s show when the room is requesting heat

What would I have done differently

- Fit solar passive heating for summer hot water
  - Requires dual coil cylinder
- Start with a new build
  - Plant room, underfloor heating, high level insulation, rain water capture, Passivhaus
  - GSHP (slinkies if landscaping necessary)
  - Solar water heating to the roof
  - Solar PV tiles with battery storage
  - Cooling for UFH in summer?

Members ASHP installations



A couple of example ASHP installations

Different sizes of heat pumps.

Hot water tank, controllers and pipe work fitted into cupboards.

Richard Care

Wendy and Patrick Busby

Heat Pump - Step by Step

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Videos + Links

See also following links

- Youtube - Fully Charged - Home Energy 5 – Heat Pumps
- MCS Certified
- Renewable Heat Incentive
- Zero Carbon Britain

My Youtube Hosted Build Videos

- Drilling the boreholes
- In the Trenches
- Replacing the water cylinder
- Post-install view of the heat pump and fittings

Contact me at:

- rccroucher@gmail.com